PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
B41F 17/00, 19/08, B41M 3/00, 7/00, G03H 1/02

A1

(11) International Publication Number: **WO 00/30854**

(43) International Publication Date: 2 June 2000 (02.06.00)

(21) International Application Number: PCT/DK99/00642

(22) International Filing Date: 19 November 1999 (19.11.99)

(30) Priority Data:
PA 1998 01518 19 November 1998 (19.11.98) DK

(71) Applicant *(for all designated States except US)*: NILPETER A/S [DK/DK]; Elmedalsvej 20, DK–4200 Slagelse (DK).

(72) Inventors; and

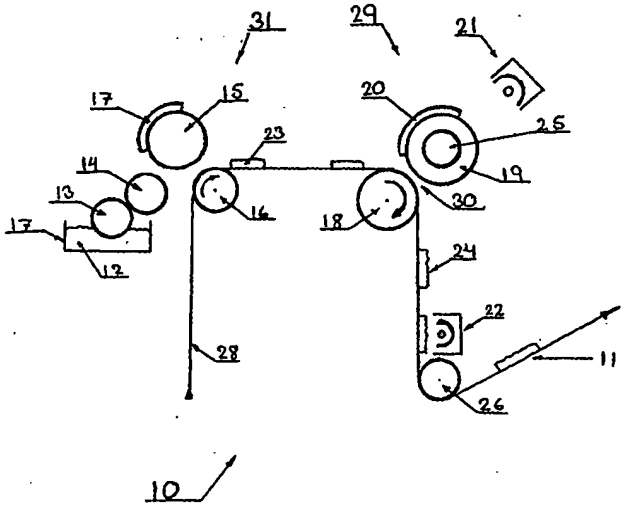
(75) Inventors/Applicants *(for US only)*: LINDVOLD, Lars [DK/DK]; Kornager 210, DK–2980 Kokkedal (DK). STENSBORG, Jan [DK/DK]; Vesterbrogade 112, st.tv., DK–1620 Copenhagen V (DK). RASMUSSEN, Torben [DK/DK]; Rosmosevej 16, DK–2650 Hvidovre (DK).

(74) Agent: PLOUGMANN, VINGTOFT & PARTNERS A/S; Sankt Annæ Plads 11, P.O. Box 3007, DK–1021 Copenhagen K (DK).

(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KR (Utility model), KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND DEVICE FOR ROTATIONAL MOULDING OF SURFACE RELIEF STRUCTURES



(57) Abstract

The present invention relates in a broad aspect to a method and a device for applying structures to a medium being conveyed on a length. The method and device utilise a moulding process in which micro structures are moulded into/onto the surface of the medium. In a specific embodiment, the present invention relates to a process facilitating the replication of microstructures in a conventional printing machine. The replication method is integrated as a part of the machine, thus making it possible to perform the application of microstructures in–line. As the replication of the microstructure takes place in–line, the application of, e.g., holograms will be in register with the printed material.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

METHOD AND DEVICE FOR ROTATIONAL MOULDING OF SURFACE RELIEF STRUCTURES

The present invention relates in a broad aspect to a method and a device for applying structures to a medium being conveyed on a length. The method and device utilise a moulding process in which micro structures are moulded into/onto the surface of the medium.

In a specific embodiment, the present invention relates to a process facilitating the replication of microstructures in a conventional printing machine. The replication method is integrated as a part of the machine, thus making it possible to perform the application of microstructures in-line. As the replication of the microstructure takes place in-line, the application of, e.g., holograms will be in register with the printed material.

BACKGRUOND FOR THE INVENTION AND INTRODUCTION TO THE INVENTION.

Application of microstructures such as holograms as an integral part of printed materials, which microstructures may be used for decoration or as a security element or a combination of both, is done when the printed material is manufactured on a rotational printing machine by transferring the hologram, which has been embossed in a previous process, to the printing material by heat embossing. Such a process is expensive as the holograms typically are embossed on a web material on which they are repeated disrespecting the repeating sequence of the printing machine being used for printing, whereby each hologram has to be positioned with respect to a corresponding picture being printed or is to be printed by the printing machine. This positioning will of course limit the production speed of the printing unit just as it increases the waste of material of the holograms.

The present invention relates to a process in which the microstructure is replicated in the printing unit and the invention render superfluous the pre-production of the microstructure holograms. A moulding process not limiting the speed of production of the printing unit provides production of the microstructure. Also the waste of the material on which the microstructures are provided to in known systems is avoided as the microstructure according to the present invention is laid down in a print colour or a lacquer almost always being a component of the printing material, for instance the microstructure may be applied

to the surface of print colour or lacquer defining the ordinary printed picture, patter and/or text .

BRIEF DESCRIPTION OF THE INVENTION

These and many more advantages have been provided by a method and a device for providing structures to medium, which method and device also solves the above-mentioned problems connected with application of the prior art methods.

In a first and broad aspect of the present invention by the invention relates to a method for providing a structure to a medium applied to a length comprising

- applying the medium to the length
- conveying the length to a moulding station
- providing at the moulding station the structure in/to the medium

and

- stabilising the medium so as to stabilise the shape of the structures provided in/to the medium.

The term structure denotes, when used herein, a geometrical pattern comprising for instance peaks and valleys whereby light when directed towards the structure is diffracted and/or reflected in a way being at least partially determined by the geometrical pattern.

The term microstructure is to be understood in the context of the present application to cover structures that have small dimensions. This term is therefor not to be construed in the sense that only structures having a characteristic length scale in the micro-meter range is considered in the invention. Therefore the scope of the claims comprises structures having a characteristic length scale below the micro-meter range, such a nano-structures and having a characteristic length scale above the micro-meter range.

Providing of the structure in/to the medium may be performed in different ways according to the present invention. Preferably, the structure is to be applied in a limited area, such as the extension of the medium, and in these cases the structure is preferably provided by an advancing front method. In this case the front (being the line separating the part of the medium which has been applied the structure and the part of the medium which has not been applied structures) advances until the whole structure has been applied to the

medium. Alternatively, the structure may be applied in a stamping like process in which the whole structure is applied to the medium at the same time.

The phrase "conveying the length" may be understood in the sense that the medium and the length are transported together to the moulding station. In some preferred embodiments, the length is a sheet having an extension being longer than the distance between the position of application and the moulding station. In this case conveying the length may preferably be construed as conveying at least the part of the length on which the medium is applied.

The stabilising is preferably a step in which the medium is treated in such a way that it may be conveyed without damaging the structure provide in/to the medium. A typical example of this is one where the medium is soft such as liquid initially and where the stabilising step hardens at least the surface of the medium.

As to be understood by the following description of the invention, the invention and the claims relates at least to the following types of structures with applications:

- moulding of micro-flow channels for instance to be used in fabrication of lab-on-a-chip systems, also known as micro total analysis systems (μTAS); in such a situation, most likely a laminating process providing a cover to the moulded path will be applied after the paths have been moulded.
- moulding of integrated optical components such as waveguides.
- moulding of structures for opto electronics such as light emitting polymer displays.
- moulding of nano-structures for cell and tissue culturing in biological and medical applications.
- holograms applicable for security and decoration
- diffractive optical elements also known as holographic optical elements
- structures for sound and image reproduction

In a broad aspect of the present invention the order in which the different steps comprised in the method is listed is not casually chosen as the order reflects a natural order for executing the different steps. Included in this statement is also the situation in which stabilising of medium occurs simultaneously or substantially simultaneously with providing of the structure.

The first step to be performed is to apply the medium to some kind of carrier length adapted to carry/convey the medium to a moulding station. The next step is to provide the structure to the medium after the medium has been conveyed/carried to the moulding station. The word moulding station is meant to include processes in which the physical properties of the medium are changed for instance during application of the structure. The change of physical properties may in certain embodiment be changed temporarily while the structure is applied where after the original properties of the medium are regained either actively or passively.

Typical changes of properties are phase changes such as from liquid to solid phase or from solid to liquid during moulding and back to solid during stabilising.

By setting the steps of the method according to the present invention in the order stated above the process of moulding the structures is divided from the process of application of the medium to the length which is found to be very advantageous as the two processes can be optimised independently of each other, thereby providing solutions to problems encountered by prior art methods/systems as will become clear in the following description of the invention.

In a preferred embodiment of the method according to the present invention the medium is being conveyed as the structure is provided. By conveying the medium while the structure is provided the speed of the method is not limited by providing the structure.

Furthermore, the stabilising of the medium may preferably occur substantially while the medium is being conveyed, such as while the medium is being provided the structure.

In a preferred embodiment of the method according to the present invention the stabilising is performed by focusing a streak of electromagnetic radiation into a focusing area for stabilising the medium in that focusing area. The focusing area is typically determined based on when in the process the stabilising is to be performed. For instance, if the stabilising is to be performed while the structure is applied the streak of electromagnetic radiation is directed towards the area in which providing of the structures takes place.

In a preferred embodiment of the method according to present invention, the streak of electromagnetic radiation is provided by directing a beam of electromagnetic radiation into the focusing area. In one embodiment of an apparatus according to the present invention this step has been embodied by use of a laser directing a laser beam towards a movable mirror reflecting the laser beam along a line thereby focusing the laser beam in the focusing area.

In a very important aspect of the present invention the method further comprises the step of post curing the medium after the structure has been provided. The post-curing step is a step which objective is to finalise or ending the providing of structure method. This is to be understood in the sense that in case the medium after the stabilising step has not gained its final physical properties such as strength, phase, colour or the like the medium is post-cured so as to provide it its final physical properties.

Typical, such post-curing steps are, post radiation, cooling of the medium, a phase in which evaporation takes place or the like. The type of the post-curing step is, of course, strongly linked to or depended on the medium and the type may be active for instance active cooling by a cooling element or the type may be passive for instance cooling by natural convection/radiation.

With respect to the general method, the invention relates in another and connected aspect also to a method utilising means for performing the different steps according to the present invention. In this case the method for providing the structure to the medium comprises

- applying the medium to the length by use of a application means, utilising impact application such as a printing unit, a flexo graphic printing unit, an offset unit, book printing unit, or the like or utilising non-impact application such as inkjet application or a syringe
- conveying the length from the application means to a moulding station comprising a rotating roller having a mould,
- providing the structures to/in the medium by contacting the medium with the mould as the length is being conveyed,

and

- stabilising the medium whereby the structures provided to/in the medium will be provided a stable shape.

The application means is/are, of course, chosen depending on what medium is to be applied and to what extend the medium is to be applied. For instance the invention also incorporate the situation in which the medium is not dosed either as portions deposited on the length or dosed so as to have certain geometrical dimensions. Also the medium may be applied as a part of a normal printing process printing pictures, text or the like on the length and the structure may be provided to the surface of medium.

In a preferred embodiment, the method for providing structure is implemented as a part, an in-line, of a normal printing process, i.e. a process in which patterns such as pictures, text or the like are applied to the length and in this embodiment - and other embodiments - the medium is preferably conveyed on a length.

Also, in a preferred embodiment, the structure may be provided in/to the medium by contacting the medium with the mould as the length is being conveyed, which preferably may be combined with stabilising of the medium substantially at the moment when the medium is in contact with the mould in a contact area. The contact area is defined as the area of the mould being in contact with the medium during moulding.

Preferably, stabilising of the medium is provided by exposing the medium to electromagnetic radiation such as x-ray, ultra violet light, infra red light, a beam of electron's and/or visible light.

In certain preferred embodiments the mould may shield the area of the medium which is to be exposed to electromagnetic radiation so that the radiation may not be exposed to the medium. In such cases, the mould may be transparent with respect to the electromagnetic radiation exposed to the medium for stabilising so that the radiation may penetrate the mould in order to influence to medium.

Also the roller eventually combined with the mould may shield the area of the medium which is to be exposed to electromagnetic radiation. In such cases the rotating roller having the mould may also be transparent with respect to the electromagnetic radiation used for stabilising the medium so that the radiation may be able to penetrate the roller as well as the mould in order to stabilise the medium.

As electromagnetic radiation often is available from a source giving either a non-focused beam or a beam focused in a small circular area, the moulding station may preferably comprise at least one means for substantially transforming the beam geometry, for instance by focusing, of the electromagnetic radiation used for stabilising the medium. The focusing means preferably focus the electromagnetic radiation in a streak extending across the medium.

The focusing means is/are in preferred embodiments of the present invention an integral part of the roller. The word integral covers in this context also the situation in which a focusing means is arranged inside a cavity of the roller in which case the focusing means may be held in place by external fixation means not connected to the roller or in which case the focusing means is rigidly connected to the roller so as to follow the motion of the roller.

The focusing means may alternatively be an integral part of the mould and/or combined with the roller having an integral focusing means.

Also in the present context, in which the method utilise named means, the medium is in certain preferred embodiment of the invention post cured after the structure has been provided. Such a post curing may preferably be provided by exposing the medium to electromagnetic radiation such as x-ray, ultra violet light, infra red light, a beam of electron's, micro waves and/or light.

In another preferred embodiment of the present invention stabilising of the structures is provided by exposing the medium to sound substantially focused in the area of contact. The frequency of the sound used for stabilising is, of course, depending of what kind of medium is used, but sound such as ultra-sonic sound may be applied in certain situations.

In preferred embodiments of the present invention the application means comprise(s) a rotating roller having an application sheet such as an application plate or the like which transfers the medium to the conveyed length by contacting the roller with the length. In a specific preferred embodiment of the present invention in which the medium is a liquid when applied to the medium the application means comprise(s) at least two rotating rollers, one of these being in contact with a reservoir for containing the medium and the rotating roller having the application sheet or the like is supplied with/takes up the medium

from at least one of the two rotating rollers. The roller being in contact with the reservoir is preferably arranged so that a part of it is submerged into the medium. By this configuration the medium is transferred from the reservoir via the roller submerged to the roller having the application sheet and finally to the length. This configuration may preferably comprise an intermediate roller arranged so that the medium is transferred from the roller submerged via the intermediate roller to the roller having the application sheet.

Besides the general method and the method utilising named means the present invention also relates to an apparatus for providing a structure to a medium applied to a length comprising

- application means, such as impact application means, preferably such as a flexo graphic printing device, a printing unit, an offset unit, book printing unit, or the like or non-impact application means such as an inkjet or a syringe application means applying the medium to the length,
- conveying means for conveying the length from the application means to a moulding station comprising a rotating roller having a mould for providing a structure to at least a part of the medium,

and

- stabilising means for stabilising at least the part of medium in which the structures provided to the medium so that the structures becomes geometrically stable.

The microstructure moulding apparatus is advantageous implemented inline with an ordinary printing process applying ordinary text and/or pictures to the length, but the moulding device may also very advantageously be used as a stand-alone device.

When used as a stand-alone device, the length is typically a sheet and the device may preferably be equipped with a sheet feeder and a transportation means adapted to transport sheets from the application station to the moulding station. Also when used as a stand-alone apparatus applying medium to a length and applying structure in/to the surface of the medium applied to the length, the length onto which the medium is to be applied is preferably winded up on a spool and the length is then fed into the device for application of the medium which in turn is provided a microstructure.

In a particular embodiment of the invention a two-component process is utilised for providing structures to a medium. In this embodiment a first component of the medium is applied to the length by use of the application means or during the application step. A second component of the medium is then applied either during providing of the structure at the moulding station or after the structure has been provided to the medium. The second component is a component which stabilises the medium. Typical two-component mediums comprise a resin and a hardener.

In preferred embodiments of the apparatus according to the present invention the apparatus comprises means adapted to enabling the different steps performed according to the method for providing structure to a medium. Such means is preferably

- stabilising means comprising means adapted for exposing electromagnetic radiation such as x-ray, ultra violet light, infra red light and/or visible light to the medium.
- a mould being transparent with respect to the electromagnetic radiation exposed to the medium for stabilising so that the radiation may penetrate the mould in order to influence to medium.
- a rotating roller having the mould being transparent with respect to the electromagnetic radiation used for stabilising the medium so that the radiation may be able to penetrate the roller as well as the mould in order to stabilise the medium.
- a mould or moulding station comprising at least one focusing means for substantially focusing the electromagnetic radiation used for stabilising the medium.
- focusing means being an integral part of the roller.
- focusing means an integral part of the mould eventually combined with focusing means being an integral part of the roller.
- post curing means for post curing the medium after the medium is stabilised.
- post curing means being adapted to expose electromagnetic radiation such as x-ray, ultra violet light, infra red light and/or light to the medium.
- stabilising means being means adapted to exposing sound substantially focused in the area of contact to the medium.
- application means comprising a rotating roller having a printing sheet, printing plate or the like which transfers the medium to the conveyed length by contacting the roller with the length

- application means comprising at least two rotating rollers, at least one of these being in contact with a reservoir for containing the medium and the rotating roller having the printing plate is supplied with/takes up the medium from at least one of the two rotating rollers.

In preferred embodiments of the method/apparatus according to the present invention, the medium is applied to the length by use of a non-impact application means such as a syringe. In that case the medium may either be applied while the length is being moved or the medium is applied during a stop of the length. This latter one might advantageously be implemented is a situation in which the movement of the length is stopped for instance for cutting out sections of the length.

In the embodiment of the invention, in which rollers are utilised in the application and moulding means, and the moulding the repeating distance between the medium may easily be changed by replacing the rollers with rollers having different diameters.

Furthermore, when the device according to the present invention is applied in-line with an ordinary printing device, the repeating distance of the moulding device may easily be made equal to the repeating distance of the ordinary printing device and the need for prior art positioning means for positioning the medium on the length has been rendered superfluous.

As mentioned above the method and apparatus according to the present invention provides a very elegant solution to the problem of providing surface structures to a medium applied to a length. One important feature of the present invention is that the method and apparatus may be able to apply the medium to the same material as has been printed, or is to be printed, in an ordinary manner. Thereby, the need for positioning a pre-produced surface relief structure relative to a position on a length in an in-line process, in which it may be a part of, has been rendered superfluous, as the method and apparatus according to the present invention replicates a structures from a mould preferably being rotating, whereby the same technology regarding repeating (step out) used in printing may be applied in connection with the present invention.

DETAILIED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the following the invention will be described in greater details and in particular preferred embodiments thereof in connection with the accompanying drawings in which

Fig. 1 shows a first preferred embodiment of a device for applying structures to a medium according to the present invention utilising the method according to the present invention,

Fig. 2 shows a surface scan of a photoresist master diffraction grating using an atomic force microscope (AFM). The depth of the grating profile is 300 nm and the period is approximately 1000 nm. The master is being the one from which a mould is made.

Fig. 3 shows a surface scan of the polydimethylsiloxane (PDMS) mould using an atomic force microscope (AFM).

Fig. 4 shows a surface scan, using an atomic force microscope (AFM), of the replica formed in an UV curable polymer from the PDMS mould.

With reference to fig. 1 a first embodiment of the present invention will now be described in greater details.

The length 28 onto which the microstructure is to be applied is transported through the holographic printing device 10 by use of rollers 16, 26 in combination with the pair of rollers 18, 19. In the preferred embodiment shown in Fig. 1 the roller 16 is the roller which drag the length 28 through the rotational moulding device. In this case the moulding device is followed by another processing station which has a roller dragging the length through the pair of rollers 18, 19 and passed the roller 26.

Also, in case the mould 20 extends all periphery of the roller the roller 25 may be set idling as the length 28 then will contact the mould 20 all time which will rotate the roller 25.

Furthermore, the printing device may comprise a wind-up roller winding up the length after it has left the printing device, i.e. after the passing the roller 26.

The rotation of the rollers is performed by motors such as electrical motors being connected directly to the shaft of the roller in question or via a transmission in case a gear is applied in order to set the rotation of the roller different from the rotation of the motor.

In case the same motor is applied for rotating both the pair of rollers 18,19 and the roller 16 a gear is inserted so as to set the peripheral speed of the all the rollers rotated equal.

A printing colour such as lacquer, glue or other radiation-post curing medium is applied to the material, the length, onto which the microstructure is to be applied. In the first embodiment of the invention that material is a length comprised of paper, plastic film, aluminium foils or the like and the application of the medium is done in a printing process.

The medium is typically chosen from the group comprising the following: radiation curable polymers such as printing inks, lacquers, adhesive or the like.

The printing process may suitable make use of flexo-printing machine comprising the medium transporting rollers 13, 14 and a cliché-roller 15 having printing plate 17. The medium 12, such as lacquer, which is contained in the trough 27 is being transferred via rollers 13, 14 to the printing plate 17 mounted on the cliché-roller 15 which by use of the roller 16 as counter pressure means transfers the lacquer partially or as a full coverage (or coating) to the length 28.

The material of the rollers 13, 14 and the material of the printing plate 17 is depending on which medium is to be applied to the length. 13 is in the preferred embodiment a pan roller which is constituted by a rubber covered roller. 14 is in the preferred embodiment a screened roller having a surface of or ceramics or steel and 17 is a photo-polymer plate or alternatively an engraved rubber plate.

Also depending on which type of medium is to be applied to the length the surface of the rollers 13, 14 and the printing plate 16 may be given a surface treatment in order to intensify the adherence properties of the surfaces. A crucial point in connection with the present invention is to be able to control that the correct amount of medium is applied to the length.

The repetition of the medium on the length may be controlled by applying more than one printing plate 17 to the roller 15 distributed along the periphery of the roller 15. In the preferred embodiment of Fig. 1 the printing plate 17 is provided as an elevation provided on a cliché extending along the whole periphery of the roller 15.

After the medium 23 has been applied to the length 28 the medium 23 is transported to the moulding station 29 for moulding the microstructure into the upper surface of the medium 23. The moulding station comprises the pair of rollers 18, 19, a transparent mould 20 being an integral part or mounted on the roller 19. The roller 19 is also transparent so as to allow for instant ultraviolet light or in general electromagnetic radiation to pass.

The nature of the surface of the mould 20 should be so that the medium 23 does not adhere to the mould when the medium 23 has been stabilised. In the preferred embodiment of the apparatus the mould 20 is manufactured from an elastomer of the type polydimetylsiloxane (PDMS) and the mould has been manufactured by taking a cast of a photo resist ~~ant~~ surface relief master or a nickel shim.

The microstructure is laid down in the transparent mould 20 mounted on the transparent moulding roller 19 comprising optics 25 for focusing radiation in a predetermined direction - in the present example the radiation is considered to be ultra violet light originating from a lamp 21 and the optics is a convex lens focusing a beam of light into a streak of light focused at the meniscus 30 between the medium 23 and the mould 20. One such convex lens is a part of a cylinder having a cross section comprising a sector of a circle and a straight line. More than one lens may be applied in the case where the microstructure is sectionalised so as to only expose light to the areas of the medium that is to be exposed.

The bulb of the lamp 21 has been partly covered by a shield so as to avoid radiation to the surrounding in order to avoid eye injuries to persons operating the holographic printing device. Furthermore, the lamp comprises a reflector for focusing the radiation in the direction of the roller 19. The lamp 21 may be located inside the roller 19, but by arranging the lamp outside the roller a self-cleaning may be obtained.

Alternatively to the use of optics, a beam of light which is swept across the meniscus area may be used. In that case a laser beam is reflected by use of a mirror and the reflection is

controlled by use of for instance a computer controlling a stepper motor turning the mirror in such a motion that the reflected light beam sweeps across the meniscus area.

As the length 28 is conveying the medium towards the pair of rollers 18, 19 the medium will at some moment contact the mould. In order to control that the medium 23 contacts the mould at the right moment (at the right position) setting or controlling of the phase angles between the roller 15 and the roller 19 must be performed. The right moment or position is where the front end of the medium 23 is being contacted by the front end of the mould (the front is seen with respect to the movement of the mould 20 and the medium 23). This controlling or setting may be provided by connecting the two rollers 15, 19 rigidly, for instance via a gear.

One way to controlling the movement of the length in relation to the phase angle of the moulding station 29 and/or the application station 31 is to provide indexing marks to the length 28. A sensor that is connected to a controlling unit controlling the phase angle of the rollers 19 and/or 15 may then read these indexing marks.

The distance between the application station 31 and the moulding station 29 must be set by adjustment of the phase angle between the rollers 15 and 19 in order for the medium 23 to meet the mould 20 at the right moment.

The moment where the microstructures laid down in the mould 20 is in contact with the medium 23 with the roller 18 acting as a counter pressure means, at least the surface of the medium 23 (made of lacquer) comprising the microstructures is stabilised by the ultra violet light exposed to the lacquer whereby a replica of microstructure laid down in the mould 20 is transferred to the surface of the medium 23.

As mentioned above the light has been focused by the optics 25 focusing the light into a streak of light in the meniscus 30 so that only the part of the medium situated in the meniscus area is stabilised, which imply that the upstream medium is not affected by the light. When the medium is stabilised it will attach more to the length 28 than to the mould 20 (the stabilising change the adherence of the surface of the medium 23 towards a less adherence) whereby it will transfer to the length at the point (area) of release, i.e. the point or area being stabilised.

The height of the meniscus 30, i.e. the distance between the surface of the mould 20 and the length 28 (measured normal to the length 28) must be adapted to the thickness of the medium 23. For instance this distance may be so that contact between bottom of valleys of the structure laid down in the mould 20 and the surface of the medium 23 is guaranteed. This measure may also be used to set the thickness of the medium, as heights of the structure are not normally allowed to contact the length 28. This indicates that the amount - or the thickness - of the structure is to be dosed so that penetration of medium 23 by the heights does not occur.

One way to assure fully contact in case the medium is compressible is to arrange the rollers 18 and 19 so that the height of the meniscus is smaller than the height of the medium 23.

After the medium has passed by the moulding station 29 an additional post curing may be needed in order to through cure the microstructure. Such an additional post curing is carried out by passing the medium 23 pass an additional source of ultra violet light 22 that is shown in the embodiment represented in fig. 1.

In another preferred embodiment of the present invention the moulding of the structure is accomplished by changing the physical properties of the medium 23. During application of the medium 23 to the length 28 it is temporarily made plastic for instance by applying heat to it. The medium 23 is then transported to the moulding station 29 and during its transportation it may become solid due to cooling.

When the medium 28 contacts the mould 20 it is exposed to radiation from the source 21 which in this embodiment will be a heat source resulting in a local plasticfication enabling changing of the surface by the mould 20. After contact with the mould 20 the medium 28 is post cured by cooling which might be active cooling by a cooling element if fast solidification is needed.

CLAIMS

1. A method for providing a structure to a medium applied to a length comprising
- applying the medium to the length
- conveying the length to a moulding station
- providing at the moulding station the structure in/to the medium

and
- stabilising the medium so as to stabilise the shape of the structures provided in/to the medium.

2. A method according to claim 1, wherein the medium is being conveyed as the structure is provided.

3. A method according to claim 1 or 2, wherein the stabilising of the medium occur substantially while the medium is being provided the structure.

4. A method according to any of the preceding claims, wherein the stabilising is performed by focusing a streak of electromagnetic radiation into a focusing area for stabilising the medium in said focusing area.

5. A method according to any of the preceding claims, wherein the streak of electromagnetic radiation is provided by directing a beam of electromagnetic radiation into the focusing area.

6. A method according to any of the preceding claims, further comprising the step of post curing the medium after the structure has been provided.

7. A method for providing a structure to a medium according to any of the preceding claims comprising

- applying the medium to the length by use of a application means, utilising impact application such as a printing unit, a flexo graphic printing unit, an offset unit, book printing unit, or the like or utilising non-impact application such as inkjet application or a syringe

- conveying the length from the application means to a moulding station comprising a rotating roller having a mould,

- providing the structures to/in the medium by contacting the medium with the mould as the length is being conveyed,

and

- stabilising the medium whereby the structures provided to/in the medium will be provided a stable shape.

8. A method according to claim 7, wherein the stabilising of the medium occur substantially when the medium is in contact with the mould in a contact area.

9. A method according to claim 7 or 8, wherein the stabilising of the medium is provided by exposing the medium to electromagnetic radiation such as x-ray, ultra violet light, infra red light, a beam of electron's and/or visible light.

10. A method according to claim 9, wherein the mould is transparent with respect to the electromagnetic radiation exposed to the medium for stabilising so that the radiation may penetrate the mould in order to influence to medium.

11. A method according to claim 10, wherein the rotating roller having the mould is transparent with respect to the electromagnetic radiation used for stabilising the medium so that the radiation may be able to penetrate the roller as well as the mould in order to stabilise the medium.

12. A method according to claim 11, wherein the moulding station further comprises at least one means for substantially focusing the electromagnetic radiation used for stabilising the medium.

13. A method according to claim 12, wherein the means for focusing is an integral part of the roller.

14. A method according to claim 12 or 13, wherein the means for focusing is an integral part of the mould.

15. A method according to any of the preceding claims, wherein the medium is post cured after the structure has been provided.

16. A method according to claim 15, wherein the post curing is provided by exposing the medium to electromagnetic radiation such as x-ray, ultra violet light, infra red light, a beam of electron's, micro waves and/or light.

17. A method according to claim 7, wherein the stabilising of the structures is provided by exposing the medium to sound substantially focused in the area of contact.

18. A method according to any of the preceding claims, wherein the application means comprises a rotating roller having an application sheet such as an application plate or the like which transfers the medium to the conveyed length by contacting the roller with the length.

19. A method according to claim 7, wherein the application means comprises at least two rotating rollers, one of these being in contact with a reservoir for containing the medium and the rotating roller having the application sheet or the like is supplied with/takes up the medium from at least one of the two rotating rollers.

20. An apparatus for providing a structure to a medium applied to a length comprising

- application means, such as impact application means, preferably such as a flexo graphic printing device, a printing unit, an offset unit, book printing unit, or the like or non-impact application means such as an inkjet or a syringe application means applying the medium to the length,
- conveying means for conveying the length from the application means to a moulding station comprising a rotating roller having a mould for providing a structure to at least a part of the medium,

and

- stabilising means for stabilising at least the part of medium in which the structures provided to the medium so that the structures becomes geometrically stable.

Comments to claim 1:

providing the structures in the medium by contacting the medium with the mould as the length is being conveyed,

- the medium does not have to be dosed
- the medium may be applied by use of a syringe
- the medium may be stabilised by letting it go back to normal
- define stable !

21. An apparatus according to claim 20, wherein the stabilising means comprises means adapted for exposing electromagnetic radiation such as x-ray, ultra violet light, infra red light and/or visible light to the medium.

22. An apparatus according to claim 21, wherein the mould is transparent with respect to the electromagnetic radiation exposed to the medium for stabilising so that the radiation may penetrate the mould in order to influence to medium.

23. An apparatus according to claim 22, wherein the rotating roller having the mould is transparent with respect to the electromagnetic radiation used for stabilising the medium so that the radiation may be able to penetrate the roller as well as the mould in order to stabilise the medium.

24. An apparatus according to claim 23, wherein the mould or moulding station comprises at least one focusing means for substantially focusing the electromagnetic radiation used for stabilising the medium.

25. An apparatus according to claim 24, wherein the focusing means is/are an integral part of the roller.

26. An apparatus according to claim 24 or 25, wherein the means for focusing is an integral part of the mould.

27. An apparatus according to any of the preceding claims further comprising post curing means for post curing the medium after the medium is stabilised.

28. An apparatus according to claim 27, wherein the post curing means is adapted to expose electromagnetic radiation such as x-ray, ultra violet light, infra red light and/or light to the medium.

29. An apparatus according to claim 28, wherein the stabilising means is means adapted to exposing sound substantially focused in the area of contact to the medium.

30. An apparatus according to any of the preceding claims, wherein the application means comprises a rotating roller having a printing sheet, printing plate or the like which transfers the medium to the conveyed length by contacting the roller with the length.

31. An apparatus according to claim any of the claims 20-30, wherein the application means comprises at least two rotating rollers, at least one of these being in contact with a reservoir for containing the medium and the rotating roller having the printing plate is supplied with/takes up the medium from at least one of the two rotating rollers.

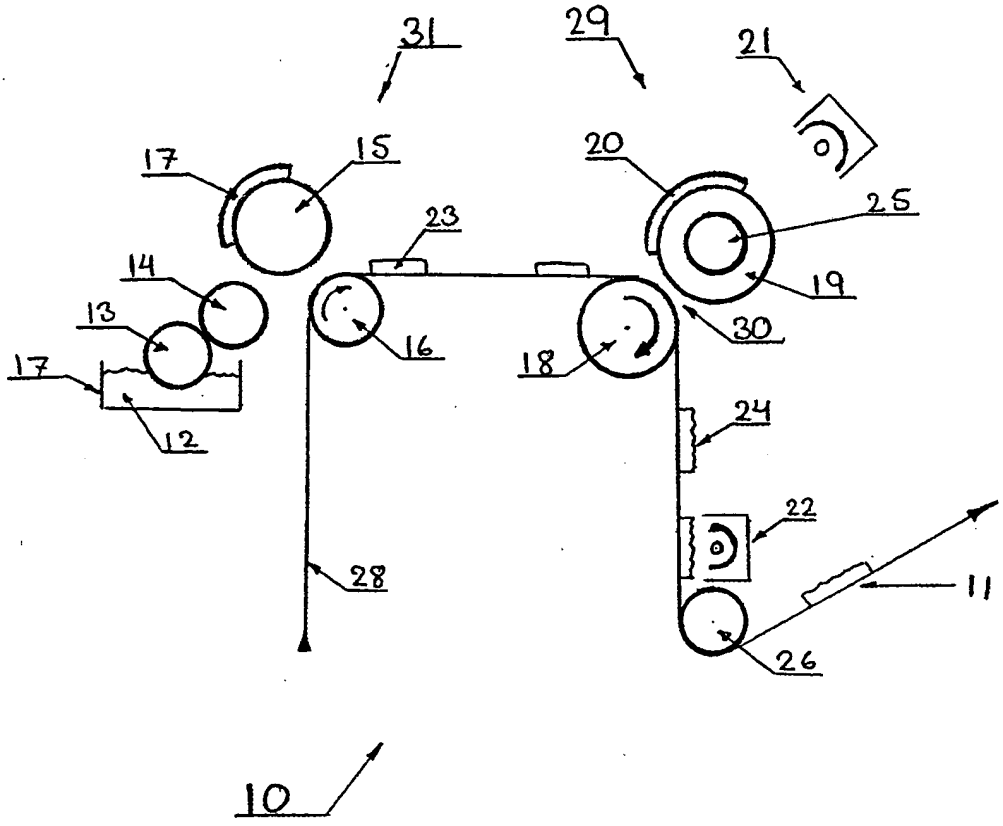


Fig. 1

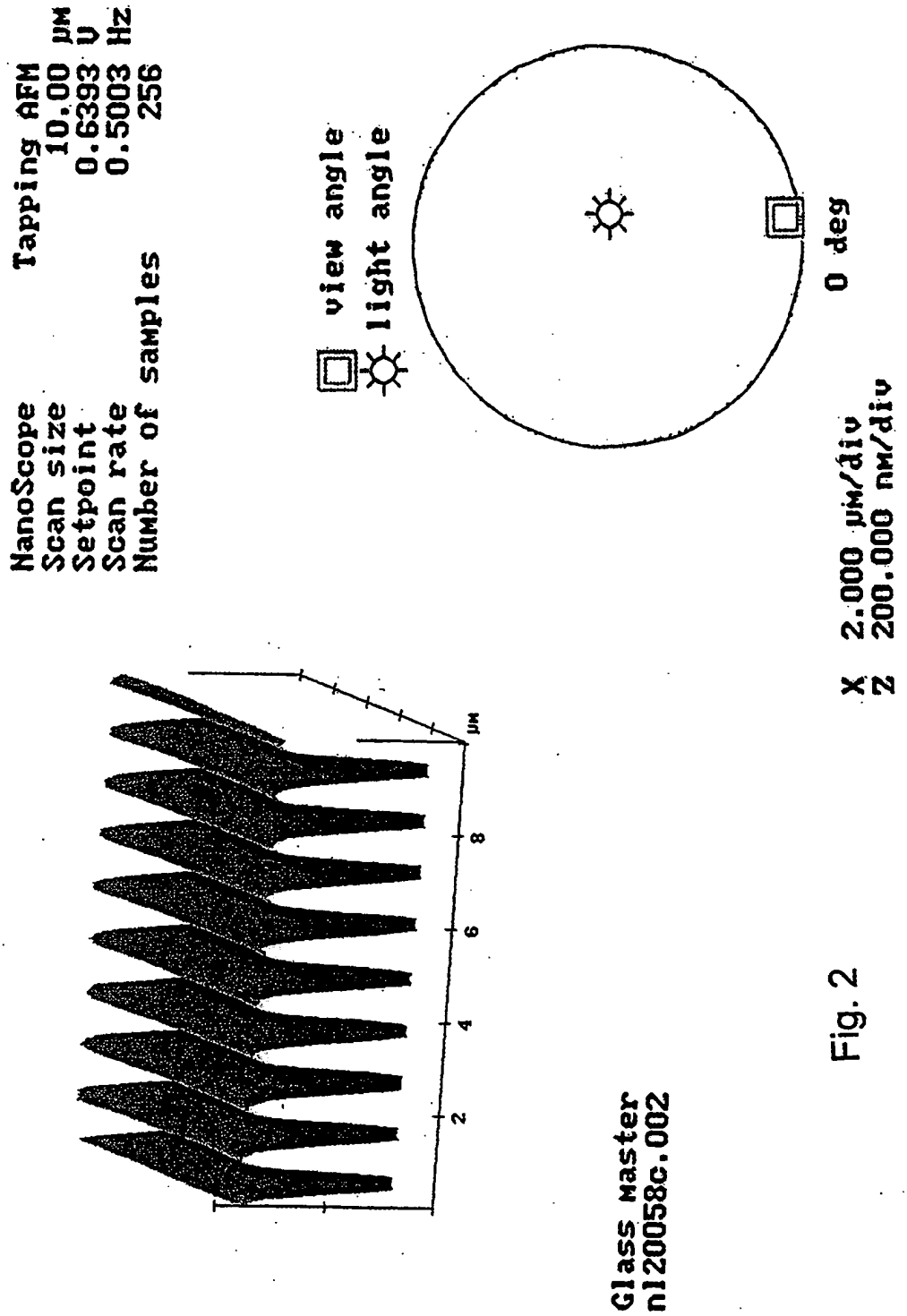

NanoScope Tapping AFM
Scan size 10.00 µm
Setpoint 0.6393 V
Scan rate 0.5003 Hz
Number of samples 256
view angle
light angle
0 deg
X 2.000 µm/div
Z 200.000 nm/div
µm
2
4
6
8
Glass master
n120058c.002

Fig. 2

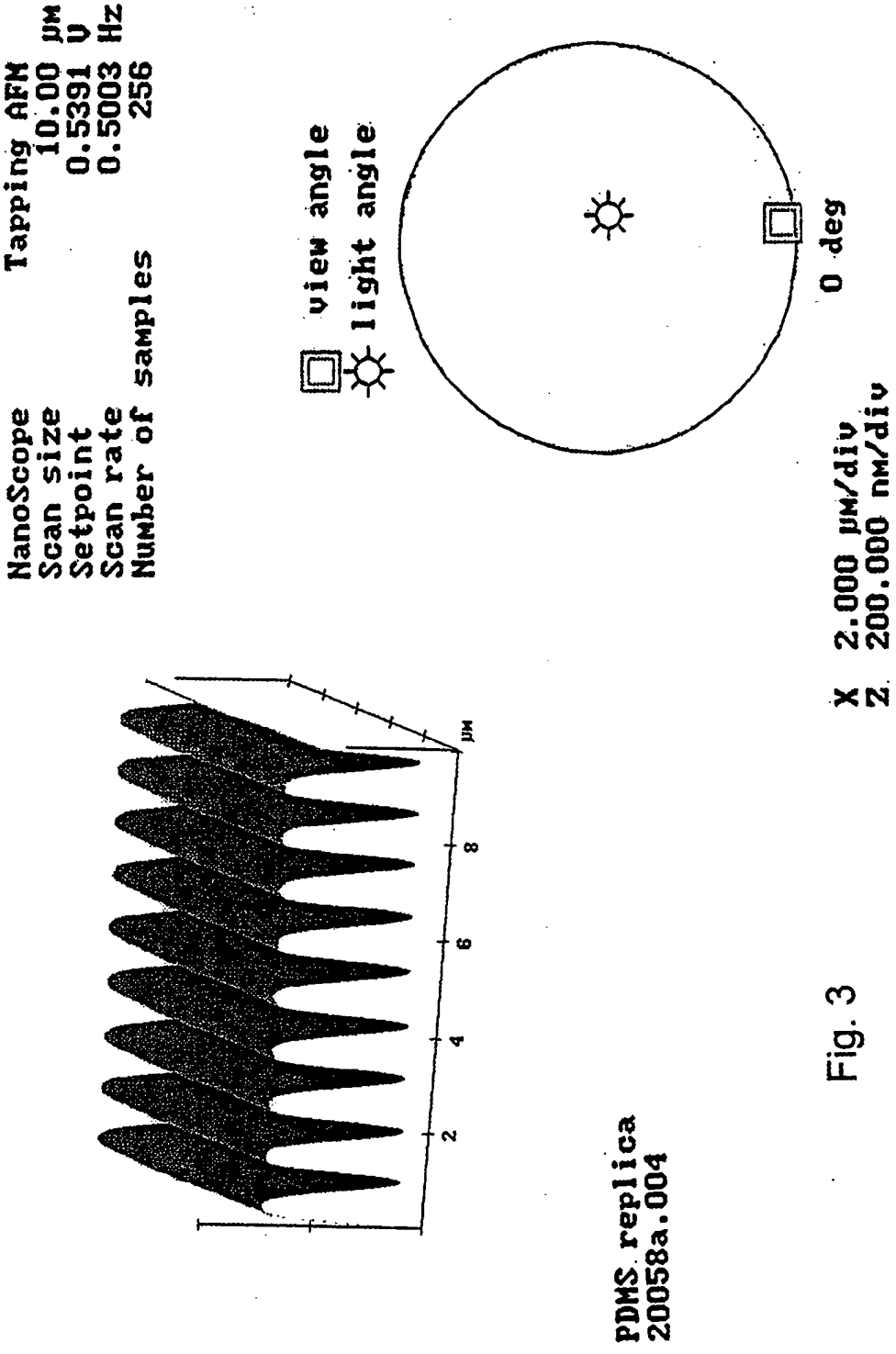

Tapping AFM
NanoScope 10.00 µm
Scan size 0.5391 V
Setpoint 0.5003 Hz
Scan rate 256
Number of samples
view angle
light angle
0 deg
X 2.000 µm/div
Z 200.000 nm/div
µm
2
4
6
8
PDMS replica
20058a.004

Fig. 3

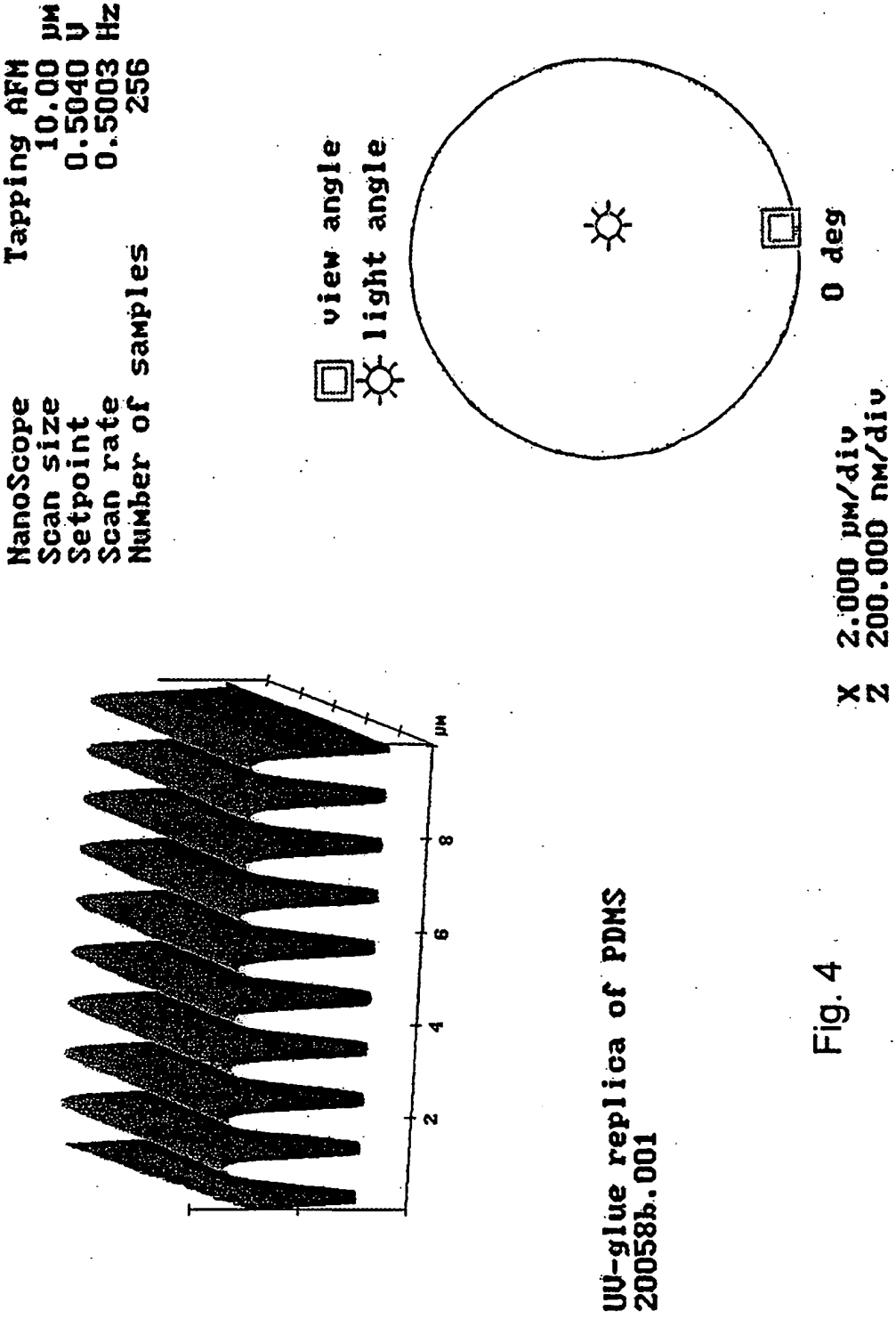

Tapping AFM
NanoScope
Scan size 10.00 µm
Setpoint 0.5040 V
Scan rate 0.5003 Hz
Number of samples 256
view angle
light angle
0 deg
X 2.000 µm/div
Z 200.000 nm/div
UV-glue replica of PDMS
20058b.001
µm
2
4
6
8

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DK 99/00642

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41F17/00 B41F19/08 B41M3/00 B41M7/00 G03H1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B41F B41M G03H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 338 378 A (AMERICAN BANK NOTE HOLOGRAPHIC) 25 October 1989 (1989-10-25) the whole document	1-9, 15-21, 27-31 10-14, 22-26
Y A	WO 94 18609 A (MATTHIESEN JOHANNES; MATTHIESEN GERDA (DE)) 18 August 1994 (1994-08-18) abstract; claims; figure 4 page 20, line 9 -page 20, line 14	10-14, 22-26 1-9, 15-21, 27-31

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 February 2000	13/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Madsen, P

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/DK 99/00642

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0338378 A	25-10-1989	US 4933120 A	12-06-1990
		AT 110640 T	15-09-1994
		AU 3311189 A	19-10-1989
		DE 68917770 D	06-10-1994
		JP 1307789 A	12-12-1989
		US 5003915 A	02-04-1991
WO 9418609 A	18-08-1994	CA 2155850 A	18-08-1994
		DE 4132476 A	01-04-1993
		AU 3448293 A	29-08-1994
		CN 1095167 A	16-11-1993
		DE 4397177 D	27-06-1996
		EP 0683903 A	29-11-1995
		JP 8508106 T	27-08-1996